



Detection of Drug-Related Problems Associated with High-Risk Medications in a Clinical Setting – A Prospective Study

Ameena Kadar K A^{*1}, Sreeja P A², Soumya P V³, Dawn V J³, Surabhi Mohan K³, Irene V R³

¹Department of Pharmacy Practice, Grace College of Pharmacy, Affiliated to Kerala University of Health Sciences, Palakkad, 678004, Kerala, India

²Department of Pharmacy Practice, Dr. M.G.R Educational and Research Institute, Velappanchavadi, Chennai, 600077, Tamil Nadu, India.

³Department of Pharmacy Practice, Sanjo College of Pharmaceutical Studies, Affiliated to Kerala University of Health Sciences, Palakkad, 678702, Kerala, India.

*Corresponding Author's Email: ameenakadar99@gmail.com

Abstract

Background: Drug-Related Problems (DRPs) associated with High-Risk Medications (HRMs) present significant challenges in clinical practice, particularly among older adults with multiple comorbidities. This study aimed to identify, classify, and address DRPs in patients prescribed HRMs at a tertiary care hospital in Kerala. **Methods:** A prospective interventional study was conducted over ten months, enrolling 201 patients aged 18 years and above, of whom 193 completed the protocol. Prescriptions involving HRMs from the cardiology, neurology, general medicine, and psychiatry departments were reviewed using the APS-Doc framework to classify DRPs. Pharmacist-led interventions were implemented to resolve identified issues, including dosage adjustments, drug substitutions, and enhanced patient monitoring. **Results:** A total of 233 DRPs were identified, with potential drug-drug interactions (61.8%) being the most prevalent, followed by actual interactions (17.6%). Ten Adverse Drug Reactions (ADRs) were reported, with Verapamil causing the most frequent reaction (peripheral oedema). Overall, 198 interventions (85%) were accepted by physicians and implemented, contributing to improved medication safety and therapeutic outcomes. **Conclusion:** The study highlighted the critical need for systematic prescription review, interdisciplinary collaboration, and proactive clinical pharmacist involvement to enhance the safety of HRMs. The APS-Doc framework proved effective in identifying and addressing DRPs, emphasising its potential for broader adoption in similar clinical settings. Future multicentre research is needed to validate these findings across diverse patient populations.

Keywords: Adverse Drug Reactions (ADRs); APS-Doc System ; Drug-Related Problems (DRPs); High-Risk Medications (HRMs)

Introduction

Medication safety remains a critical priority worldwide, as prescribing errors have been reported in nearly 9% of prescriptions, contributing to patient harm in 1 out of every 7 cases, and even fatalities among outpatients and inpatients (Leahy *et al.*, 2024; Hodkinson *et al.*, 2020). More than half of these harms are considered preventable, with medication-related problems constituting a significant proportion. High-Risk Medications (HRMs) present an even greater challenge due to their narrow therapeutic index and the heightened risk of severe harm if misused (Aradhya *et al.*, 2023; Donnelly *et al.*, 2025). Professional bodies such as the Institute for Safe Medication Practices and the American Society of Health-System Pharmacists have developed HRM formularies to mitigate these

risks, but errors involving HRMs, though not necessarily more frequent, can have catastrophic consequences.

Drug-Related Problems (DRPs), defined as events or circumstances that interfere with desired therapeutic outcomes, are well recognised as a major contributor to medication-related harm, poor clinical outcomes, and higher healthcare costs (Prasad *et al.*, 2024). DRPs may emerge at any stage of medication use, including adverse drug reactions, therapeutic ineffectiveness, harmful interactions, dosage errors, and patient non-adherence. Inappropriate drug selection further compounds these risks, making systematic identification and resolution essential to promote safe and effective medication use (ISMP, 2024).

The APS-Doc system is a structured hierarchical framework designed to identify, classify, and address DRPs in hospital settings. It organises DRPs into ten primary categories and 48 subcategories, supporting clinical pharmacists and pharmacy interns in tasks such as medication reconciliation and therapy optimisation (Hohmann *et al.*, 2021; Lekpittaya *et al.*, 2024). By enhancing documentation and promoting interdisciplinary collaboration, the APS-Doc system helps improve therapeutic outcomes and reduce the risk of drug-related harm.

Despite these advances, the implementation and adaptation of such frameworks in diverse healthcare settings remain limited. HRMs and DRPs continue to challenge medication safety and require systematic, evidence-based solutions. This study, therefore, aimed to evaluate the effectiveness of a structured framework for identifying and addressing DRPs among patients prescribed HRMs, with the goal of improving medication safety practices and advancing patient care.

Material & Methods

This prospective interventional study was conducted over a nine-month period, from January 2024 to September 2024, at a tertiary care hospital in Kerala. Participants were recruited using a convenience sampling method, based on predefined inclusion and exclusion criteria. The inclusion criteria comprised inpatients and outpatients aged 18 years and above, newly prescribed HRMs in the cardiology, neurology, general medicine, or psychiatry departments, regardless of gender, and willing to provide informed consent. Patients who were pregnant, lactating, or discharged against medical advice (DAMA) were excluded. Informed consent was obtained from all participants prior to data collection, which commenced following approval from the institutional ethics committee.

A structured data collection form was utilised to document patient demographics, medical and medication histories, diagnoses, and treatment details. Data were collected systematically, with inpatient data gathered over six consecutive days each week, and outpatient data collected on randomly selected days according to departmental schedules: General Medicine (Monday and Tuesday), Psychiatry (Wednesday and Thursday), and Neurology and Cardiology (Friday and Saturday). Patient information was retrieved from the hospital's electronic health information system (Hysan) to ensure comprehensive and accurate data capture.

Prescriptions involving HRMs were analysed according to the guidelines established by the Institute for Safe Medication Practices (ISMP) and categorised by department and Anatomical Therapeutic Chemical (ATC) codes. DRPs were identified and classified using the APS-Doc framework, enabling detailed analysis and targeted resolution of medication-related issues. Potential drug interactions were assessed using the Medscape Drug Interaction Checker. Pharmacist-led interventions were performed wherever significant DRPs were identified, with the aim of mitigating risks and optimising therapeutic outcomes.

Follow-up data, including adverse drug reactions (ADRs), were collected through direct or telephone interviews to evaluate medication safety and treatment effectiveness. ADRs were coded according to the Medical Dictionary for Regulatory Activities (MedDRA) system. The methodology was self-designed but adapted from the work of Subbaiah *et al.* (2021) to suit the hospital's clinical workflow.

Table 1: APS-Doc Classification of Drug-Related Problems (Sunny et al., 2022)

CLASSIFICATION OF DRPs	DESCRIPTION OF DRPs
Drug	Incorrect spelling
Dosage form/Dosage Strength	Wrong dosage form prescribed Wrong dosage strength prescribed No drug strength prescribed
Dosage	Prescription of an incorrect dosage or no dosage prescribed
Drug-drug interaction	Potential drug-drug interaction Actual drug-drug interaction
Adverse drug reaction	Symptoms of an adverse drug reaction
Indication	Drugs missing or suboptimal dosage

The collected data were entered into Microsoft Excel 2016, and statistical analyses, including descriptive statistics such as frequency and percentage, were performed using SPSS version 21.0 to derive meaningful insights.

Ethical Consideration

The institutional Ethics Committee of Paalana Institute of Medical Sciences, Palakkad, Kerala, approved the study on 08.01.2024 (approval reference PALIMS/EC/02/23), following submission of the research protocol in December 2023.

Results

A total of 201 patients were enrolled in this study, but 8 of them dropped out due to death (4), DAMA (2), and incomplete data of the patients (2) from the study site, remaining 193 (n=193) Patients were included in this study.

Table 2: Details of the Study Population

Details of the Study Participants		
	No. of Patients (193)	Percentage (%)
Age Group in Years		
Young Adults (18-39)	31	16.1
Middle-Aged Adults (40 -59)	41	21.2
Older Adults/ Geriatrics (60-99)	121	62.7
Gender		
Male	91	47.2
Female	102	52.8
Patient Setting		
Inpatients	145	75.1
Outpatients	48	24.9
Department		
General Medicine	86	44.6
Neurology	79	40.9
Cardiology	15	7.8
Psychiatry	13	6.7

The study population consisted of 193 patients, categorised into three age groups to assess the distribution of HRMs prescriptions across different life stages. Young adults, aged 18 to 39 years, comprised 16.1% of the study population, with 31 patients falling within this category. Middle-aged adults, aged 40 to 59 years, accounted for 21.2% of the patients, representing a slightly larger proportion with 41 individuals. The majority of the study participants, however, were older adults or geriatric patients aged 60 to 99 years, who made up 62.7% of the total population, encompassing 121 patients. This age distribution highlights the higher prevalence of HRMs prescriptions among older adults, likely reflecting the increased burden of chronic conditions and complex medication regimens in this age group compared to younger populations (Leahy *et al.*, 2024).

Out of the 193 patients in the study, 52.8% (102 patients) were female, and 47.2% (91 patients) were male. This shows a nearly equal distribution of genders, with a slightly higher number of female participants. The majority of participants 75.1% (145 patients) were inpatients, likely reflecting the need for intensive monitoring and management associated with conditions requiring HRMs. In contrast, 24.9% (48 patients) were outpatients, receiving treatment while living outside the hospital. This highlights the prevalence of HRMs prescriptions in settings demanding close supervision to ensure patient safety. Among the enrolled patients, 44.6% (86 individuals) were from the General Medicine department, emphasising its key role in managing conditions that require HRMs. Neurology followed as the second-largest group, accounting for 40.9% (79 patients), highlighting its substantial use of HRMs for neurological conditions. Cardiology contributed 7.8% (15 patients), reflecting its smaller yet vital involvement in prescribing HRMs for cardiovascular issues. Psychiatry made up 6.7% (13 patients), representing its role in addressing psychiatric conditions with HRMs. This distribution showcases the wide range of departments utilising HRMs, with General Medicine and Neurology being the most prominent contributors.

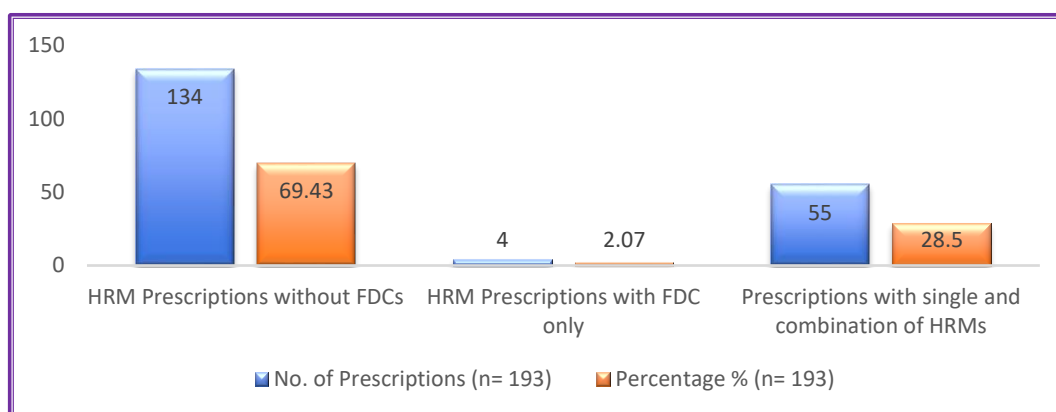


Figure 1: Prescribing Pattern of HRMs

The analysis of HRMs prescription patterns among the 193 patients revealed three distinct categories. A majority, 69.43% (134 prescriptions), consisted of HRM prescriptions without fixed-dose combinations (FDCs), indicating the frequent use of standalone HRMs. Only a small proportion, 2.07% (4 prescriptions), involved prescriptions containing FDCs exclusively, highlighting the relatively limited utilisation of fixed-dose formulations for HRMs. Meanwhile, 28.50% (55 prescriptions) included a combination of single HRMs and FDCs, reflecting a more complex prescribing pattern where both standalone and combination HRMs were used together to address patient needs. This distribution underscores the predominance of standalone HRMs in prescriptions while also demonstrating the occasional reliance on combinations for specific therapeutic purposes.

Table 3: Department Wise Distribution of HRMs

Department	Frequency of HRMs	Percentage (%)
General Medicine	385	57.21
Neurology	144	21.40
Psychiatry	79	11.74
Cardiology	65	9.65

At the study site, 84 HRMs were identified and categorised based on departmental and pharmacological classifications, along with their respective ATC codes. A total of 673 instances of HRMs were prescribed across the study site and distributed among various departments. The majority were from the General Medicine department, accounting for 385 prescriptions (57.21%), followed by Neurology with 143 prescriptions (21.40%). Psychiatry contributed 79 prescriptions (11.74%), while Cardiology accounted for 65 prescriptions (9.65%). This distribution highlights the prominent role of General Medicine and Neurology in prescribing HRMs, reflecting their broader patient base and diverse therapeutic needs.

Table 4: HRMs Prescribed in Cardiology and Its ATC Code

HRMs	Frequency (n=65)	ATC Code
Noradrenaline	1	C01CA03
Labetalol	2	C07AG01
Metoprolol	12	C07AB02
Amiodarone	4	C01BD01
Digoxin	7	C01AA05
Verapamil	3	C08DA01
Enoxaparin	10	B01AB05
Heparin	17	B01AB01
Acenocoumarol	1	B01AA07
Apixaban	1	B01AF02
Warfarin	4	B01AA03
Potassium Chloride	2	B05XA01
Magnesium Sulfate	1	B05XA05

The Department of Cardiology prescribed a variety of HRMs for cardiovascular care. Commonly used drugs included adrenergic agents like Noradrenaline and Labetalol, beta-blockers such as Metoprolol, and anti-arrhythmics like Amiodarone, Digoxin, and Verapamil. Anticoagulants, including Enoxaparin, Heparin, Warfarin, Acenocoumarol, and Apixaban, were frequently prescribed. Additionally, electrolytes like Potassium Chloride and Magnesium Sulfate were utilised, showcasing a comprehensive approach to cardiovascular management.

Table 5: HRMs Prescribed in General Medicine and Its ATC Code

HRMs	Frequency (n =385)	ATC Code
Insulin	36	A10AB
Metformin	46	A10BA02
Glimepiride	32	A10BB12
Sitagliptin	27	A10BH01
Dapagliflozin	6	A10BK01
Glipizide	2	A10BB07
Vildagliptin	4	A10BH02
Voglibose	2	A10BF03
Teneligliptin	1	A10BH13
Amoxicillin with Clavulanic Acid	10	J01CR02
Penicillin G	1	J01CE01
Ampicillin	1	J01CA01
Piperacillin with Tazobactam	27	J01CR05
Ceftriaxone	34	J01DD04
Cefoperazone	27	J01DD02
Cefixime	31	J01DD08
Cefpodoxime	17	J01DD13
Cefuroxime	1	J01DC02
Meropenem	17	J01DH02
Faropenem	15	J01DI03
Levofloxacin	4	J01MA12
Ciprofloxacin	7	J01MA02
Azithromycin	20	J01FA10
Amikacin	4	J01GB06
Linezolid	4	J01XX08
Fluconazole	1	J02AC01
Methotrexate	1	L04AX03
Promethazine Injection	1	R06AD02
Tranexamic Acid	6	B02AA02

The Department of General Medicine utilised a variety of HRMs to manage diverse medical conditions. Metformin is the most frequently prescribed drug, with around 46 prescriptions, followed by Insulin, Ceftriaxone, and Glimepiride, each of which has high utilisation, indicating their significant role

in managing chronic conditions like DM. Other drugs, such as Cefixime, Sitagliptin, and Piperacillin with Tazobactam, also show considerable prescription counts, reflecting their prevalent use in treating infections and other medical conditions. Medications such as Tranexamic Acid, Fluconazole, Methotrexate, and Promethazine Injection highlighted the department's commitment to addressing complex therapeutic needs comprehensively.

Table 6: HRMs Prescribed in Neurology and its ATC Code

HRMs	Frequency (n=144)	ATC Code
Carbamazepine	5	N03AF01
Gabapentin	13	N03AX12
Lamotrigine	1	N03AX09
Levetiracetam	28	N03AX14
Divalproex	2	N03AX01
Clonazepam	26	N03AE01
Lacosamide	5	N03AX18
Pregabalin	16	N03AX16
Phenytoin	3	N03AB02
Clobazam	6	N05BA09
Primidone	1	N03AA03
Sodium Valproate	6	N03AG01
Oxcarbazepine	1	N03AF02
Brivaracetam	5	N03AX23
Trihexyphenidyl	5	N04AA01
Amantadine	3	N04BB01
Pramipexole	1	N04BC05
Oseltamivir	16	J05AH02
Tenecteplase	1	B01AD11

The Department of Neurology utilised a wide array of HRMs to manage neurological and related conditions, with a strong focus on antiepileptic drugs. Commonly prescribed antiepileptics included Levetiracetam, Clonazepam, Gabapentin, and Pregabalin, addressing seizure disorders and neuropathic pain. Other notable antiepileptics included Carbamazepine, Phenytoin, Sodium Valproate, and newer agents like Brivaracetam and Lacosamide. Adjunct therapies included Clobazam for seizure management and Trihexyphenidyl, Amantadine, and Pramipexole for movement disorders. Additionally, Oseltamivir was utilised for antiviral therapy, and Tenecteplase was prescribed for acute neurological emergencies, reflecting the department's comprehensive approach to treating a diverse patient population.

Table 7: HRMs Prescribed in Psychiatry and Its ATC Code

HRMs	Frequency (n=79)	ATC Code
Alprazolam	6	N05BA12
Fluoxetine	3	N06AB03
Sertraline	3	N06AB06
Escitalopram	11	N06AB10
Duloxetine	8	N06AX21
Dosulepin	1	N06AA16
Amitriptyline	1	N06AA09
Mirtazapine	2	N06AX11
Nortriptyline	2	N06AA10
Venlafaxine	1	N06AX16
Lorazepam	11	N05BA06
Etizolam	1	N05BA19
Olanzapine	2	N05AH03
Risperidone	6	N05AX08
Quetiapine	11	N05AH04
Haloperidol	9	N05AD01
Aripiprazole	1	N05AX12

The Psychiatry department employed a variety of HRMs to manage mental health conditions, with a focus on antidepressants, antipsychotics, and anxiolytics. Among antidepressants, Escitalopram, Duloxetine, and Fluoxetine were commonly used, alongside others like Amitriptyline, Nortriptyline, and Venlafaxine. Anxiolytics such as Lorazepam and Alprazolam were frequently prescribed, reflecting their importance in managing anxiety-related disorders. Antipsychotic medications included Quetiapine, Haloperidol, Risperidone, and Olanzapine, addressing psychotic conditions and mood stabilization. Other agents, such as Etizolam and Aripiprazole, were prescribed less frequently, showcasing the department's tailored approach to treating a range of psychiatric conditions.

Table 8: DRPs Encountered in the Prescriptions

DRPs	No. of DRPs from the Prescriptions with HRMs (n=233)	Percentage (%)
Incorrect spelling	18	7.73
Wrong dosage form prescribed	3	1.28
No dosage form prescribed	3	1.28
Incorrect dosage	5	2.15
No dosage prescribed	13	5.58
Drugs missing	6	2.58
Actual Drug Interactions	41	17.6
Potential Drug Interactions	144	61.8

The analysis of Drug-Related Problems (DRPs) in prescriptions involving HRMs identified a total of 233 issues, highlighting various prescribing errors and risks that could compromise patient safety and therapeutic outcomes. These DRPs were categorised and analysed using the APS-Doc system, a robust hierarchical framework designed to systematically classify, document, and address DRPs. The APS-Doc system facilitated the identification of specific problems across multiple categories, ensuring a structured approach to optimising medication safety (Lekpittaya *et al.*, 2024).

Table 9: ADRs Encountered in the Prescriptions of HRMS and Its Meddra Code

Sl no.	Drug	Reaction	MedDRA Code	Frequency
1	Dapagliflozin	Diabetic Ketoacidosis	10012671	1
2	Heparin	Hematoma	10018854	1
3	Verapamil	Peripheral Edema	10030124	2
4	Doxycycline	Diarrhea	10012727	1
5	Piperacillin with Tazobactam	Hypokalemia	10020795	1
6	Amantadine	Dizziness, Vestibular disturbances	10013573, 10047135	1
7	Haloperidol	Insomnia, irrelevant speech, hallucinatory behavior	10020748, 10055393, 10019211	1
8	Cefoperazone with Sulbactam	Vomiting	10047700	1
9	Carbamazepine	Hyponatremia	10020772	1
Total				10

Potential drug interactions were the most frequently encountered DRPs, accounting for 61.8% (144 instances) (Jayakumar *et al.*, 2021). These represented combinations of medications with a high likelihood of adverse interactions, underscoring the importance of proactive prescription reviews. Actual drug interactions were the second most prevalent, occurring in 17.6% (41 instances) of prescriptions, where confirmed interactions posed immediate risks to patient safety. Other DRPs

included incorrect spelling (7.73%, 18 instances), which could lead to errors in medication dispensing or administration. Additionally, 5.58% (13 instances) of prescriptions lacked a specified dosage, increasing the risk of under dosing or overdosing. Errors such as incorrect dosage (2.15%, 5 instances), wrong dosage form prescribed (1.28%, 3 instances), and no dosage form prescribed (1.28%, 3 instances) further illustrated gaps in prescription accuracy and completeness. Furthermore, drugs missing in prescriptions were identified in 2.58% (6 instances), indicating incomplete or inadequate medication regimens.

Among the study population, 10 patients experienced Adverse Drug Reactions (ADRs), which were categorised using the MedDRA coding system. The reported ADRs included diabetic ketoacidosis linked to Dapagliflozin, hematoma caused by Heparin, peripheral edema associated with Verapamil, diarrhea from Doxycycline, and hypokalemia due to Piperacillin with Tazobactam. Other ADRs included dizziness and vestibular disturbances from Amantadine, insomnia, irrelevant speech, and hallucinatory behavior caused by Haloperidol, vomiting linked to Cefoperazone with Sulbactam, and hyponatremia associated with Carbamazepine. Verapamil accounted for the highest frequency, with two cases of peripheral edema, while other medications were each associated with a single reaction. Of the 10 affected patients, 8 were withdrawn from the suspected medications. For those who developed peripheral edema from Verapamil, Torsemide was prescribed to alleviate the condition.

Interventions

A total of 233 pharmacist interventions were proposed to address the identified DRPs. Among these, 198 interventions (85%) were accepted and implemented by the treating physicians. The interventions included clarifications of 18 spelling errors, corrections of 3 wrong dosage forms, specification of 3 missing dosage forms, 5 dosage adjustments, completion of 13 missing dosages, and inclusion of 6 omitted drugs. For drug interactions, 41 actual interactions were addressed through therapy modifications or substitutions, while 144 potential interactions were managed primarily through patient counselling and enhanced monitoring. Most of these potential drug interactions were related to metabolic pathways, and actual interactions were carefully evaluated by physicians, who considered patient-specific clinical conditions and adjusted treatment plans accordingly.

In addition, ten ADRs were identified during the study. Of these, eight patients were withdrawn from the suspected medication, while two continued therapies with supportive management. All ADRs were coded and classified according to the MedDRA system. These pharmacist-led interventions collectively contributed to optimising patient safety and improving therapeutic outcomes.

Discussion

The present study provided important insights into the prevalence and nature of DRPs associated with HRMs in a tertiary care setting. The predominance of DRPs among older adults (62.7% of participants) was consistent with previous reports highlighting the burden of polypharmacy and multimorbidity in geriatric populations (Huang *et al.*, 2021). The highest number of HRM prescriptions originated from the general medicine and neurology departments, indicating their critical roles in managing complex, chronic conditions that required meticulous pharmacotherapy oversight.

Potential drug-drug interactions were the most frequently identified DRPs, accounting for 61.8% of all issues. This observation aligned with previous studies suggesting that HRMs with narrow therapeutic indices were highly susceptible to metabolic and pharmacodynamic interactions (Niu, Straubinger & Mager, 2019). While most potential interactions were managed through proactive monitoring and patient counselling, actual interactions (17.6%) necessitated immediate therapy adjustments, underscoring the importance of continuous clinical pharmacist involvement in real-time prescription reviews (Ghimire *et al.*, 2022).

ADRs were reported in 10 patients, with Verapamil accounting for the most frequent ADR (peripheral oedema). Timely pharmacist interventions, including withdrawal of suspected medications, substitutions, and supportive measures, were essential to minimise harm and maintain therapeutic

effectiveness. These results reinforced the value of integrating ADR surveillance with routine DRP monitoring to ensure holistic medication safety (Subbaiah *et al.*, 2021).

The implementation of the APS-Doc classification system was particularly helpful for systematically identifying, documenting, and resolving DRPs. Such frameworks could be instrumental in improving medication safety practices, encouraging interdisciplinary collaboration, and supporting safer prescribing in high-risk patient populations (Lekpittaya *et al.*, 2024).

Limitations

A key limitation of this study was its single-centre design and the use of convenient sampling, which might limit the generalisability of the findings. Further multicentre studies with larger and more diverse populations would be warranted to confirm these results and refine DRP management approaches in different healthcare contexts. Nonetheless, these findings emphasised the pressing need for structured clinical decision support systems and routine pharmacist-led interventions to optimise the safe use of HRMs.

Conclusion

This study demonstrated that DRPs are highly prevalent in HRM prescriptions, with potential drug-drug interactions and inappropriate prescribing patterns as the leading contributors. Timely pharmacist-led interventions, supported by frameworks such as the APS-Doc system, effectively reduced the risks associated with these problems and improved patient safety. These findings highlight the importance of systematic prescription reviews, proactive ADR management, and interdisciplinary collaboration to enhance medication safety. Further research is recommended to expand and validate these strategies in broader healthcare settings.

Conflict of Interest

The authors declare that they have no competing interests.

Acknowledgment

The authors extend their sincere gratitude to the Hospital for their support and for allowing them to conduct this study. Authors also thank the patients and hospital staff for their invaluable cooperation.

References

- Aradhya, P. J., Ravi, R., Chandra, B. J. S., Ramesh, M., & Chalasani, S. H. (2023). Assessment of medication safety incidents associated with high-alert medication use in intensive care setting: A clinical pharmacist approach. *Indian Journal of Critical Care Medicine: Peer-reviewed, Official Publication of Indian Society of Critical Care Medicine*, 27(12), 917–922. <https://doi.org/10.5005/jp-journals-10071-24588>.
- Donnelly, M., Fang, L., Madabushi, R., Zhu, H., Luke, M., Canterbury, C., ... & Zhao, L. (2025). Narrow Therapeutic Index Drugs: FDA Experience, Views, and Operations. *Clinical Pharmacology & Therapeutics*, 117(1), 116-129. <https://doi.org/10.1002/cpt.3460>.
- Ghimire, R., Prasad, P., Parajuli, S., Basnet, R., Lamichhane, P., Poudel, N., ... & Mudvari, A. (2022). Potential drug-drug interaction among the patients admitted in Intensive Care Units of a tertiary care centre: A descriptive cross-sectional study. *JNMA: Journal of the Nepal Medical Association*, 60(247), 263-267. <https://doi.org/10.31729/jnma.7137>
- Hodkinson, A., Tyler, N., Ashcroft, D. M., Keers, R. N., Khan, K., Phipps, D., Abuzour, A., Bower, P., Avery, A., Campbell, S., & Panagioti, M. (2020). Preventable medication harm across health care settings: A systematic review and meta-analysis. *BMC Medicine*, 18(1), 313. <https://doi.org/10.1186/s12916-020-01774-9>
- Hohmann, C., Eickhoff, C., Klotz, J. M., Schulz, M., & Radziwill, R. (2012). Development of a classification system for drug-related problems in the hospital setting (APS-Doc) and assessment of the inter-rater reliability: Classification system for drug-related problems in the hospital setting (APS-Doc). *Journal of Clinical Pharmacy and Therapeutics*, 37(3), 276–281. <https://doi.org/10.1111/j.1365-2710.2011.01281.x>

Huang, Y. T., Steptoe, A., Wei, L., & Zaninotto, P. (2021). The impact of high-risk medications on mortality risk among older adults with polypharmacy: Evidence from the English Longitudinal Study of Ageing. *BMC Medicine*, 19, 1-13. <https://doi.org/10.1186/s12916-021-02192-1>

Institute for Safe Medication Practices (ISMP). (2024). *ISMP high-alert medications: Acute care setting*. Institute for Safe Medication Practices. <https://www.ismp.org/recommendations/high-alert-medications-acute-list>

Jayakumar, A., Abraham, A. S., Kumar, S., Chand, S., George, S. M., Joel, J. J., & Up, N. (2021). Critical analysis of drug related problems among inpatients in the psychiatry department of a tertiary care teaching hospital: A pharmacist led initiative. *Clinical Epidemiology and Global Health*, 11, 100743. <https://doi.org/10.1016/j.cegh.2021.100743>

Leahy, I. C., Staffa, S. J., Charolia, S., Baier, A. W., Richards, M., & Brustowicz, R. M. (2024). Enhancing medication safety: Description of characteristics of medication errors and effectiveness of quality improvement strategies. *JCA Advances*, 1(3-4), 100073. <https://doi.org/10.1016/j.jcadva.2024.100073>.

Lekpittaya, N., Kocharoen, S., Angkanavisul, J., Siriudompas, T., Montakantikul, P., & Paiboonvong, T. (2024). Drug-related problems identified by clinical pharmacists in an academic medical centre in Thailand. *Journal of Pharmaceutical Policy and Practice*, 17(1), 2288603. <https://doi.org/10.1080/20523211.2023.2288603>.

Niu, J., Straubinger, R. M., & Mager, D. E. (2019). Pharmacodynamic Drug-Drug Interactions. *Clinical Pharmacology and Therapeutics*, 105(6), 1395–1406. <https://doi.org/10.1002/cpt.1434>

Prasad, N., Lau, E. C., Wojt, I., Penm, J., Dai, Z., & Tan, E. C. (2024). Prevalence of and risk factors for drug-related readmissions in older adults: a systematic review and meta-analysis. *Drugs & Aging*, 41(1), 1-11. <https://doi.org/10.1007/s40266-023-01076-8>

Subbaiah, M. V., Babu, K. L. P., Manohar, D., Sumalatha, A., Mohammed, P., & Mahitha, B. (2021). Drug utilization evaluation of high alert medications in intensive care units of tertiary care teaching hospital. *Journal of Drug Delivery and Therapeutics*, 11, 94–101. <https://doi.org/10.22270/jddt.v11i1-s.4749>

Sunny, M., K, N., Aathif, M., Subramanya, C., Chand, S., U.P., N., & Chacko, C.S. (2022). Assessment of drug-related problems among geriatric inpatients: an APS-doc classification system-based study. *Aging Medicine and Healthcare*, 13(4), 163-169. <https://doi.org/10.33879/amh.134.2021.07069>